"Method for simulating communication networks, related simulator, communication network, and computer program product"

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5   Field of the invention

The invention relates to techniques for simulating communication networks.

Simulation is an essential step in planning, designing, constructing and operating such networks,
10   especially in view of optimising network performance. In particular, simulation plays an important role both in terms of verifying the planning of a new network, and in terms of upgrading and optimising the performance of an already fielded network.

15   The invention was devised focusing on its possible application to the simulation of telecommunication networks, such as cellular mobile radio networks, such simulations having joint nature, involving, for instance – both second generation systems (2G systems)
20   such as GSM and GPRS, and third generation systems (3G systems) such as UMTS (CDMA2000).

Reference to said specific application, however, is not to be construed as limiting the scope of the invention, which is wholly general.

25   Description of the prior art

Existing system simulators can be used, for example, to simulate cellular mobile radio networks; they are characterised by an object architecture, as described for instance in WO-A-02/104055.

30   The object based approach entails an alternative manner of breaking a project down: in this approach, the elementary break-down unit is not the operation (the procedure) but the object, construed as a model of a real entity (an object of the real world). In such
35   simulators are present modules or devices with the

ability to simulate the behaviour of the physical network devices, as well as a highly flexible engine which allows, for example, to handle joint GSM/GPRS/UMTS simulations.

5   Based on the known simulation architecture, however, the implementation needed to conduct simulations where second generation system calls take place simultaneously with third generation system calls is particularly onerous and complex. Based on the prior

10 art architecture, all devices representing the physical network devices must be designed and implemented entirely for each system to be simulated: for instance, when simulating GPRS and UMTS systems with an HTTP application, it is necessary to design and implement

15 two versions of the HTTP application, one for the GPRS system and one for the UMTS system.

The Applicant has observed that, using the architecture disclosed by WO-A-02/104055, it is very complicated to extend the simulation capability to new

20 systems, in particular new cellular systems to be simulated: this operation requires on each occasion the design and implementation of the modules/devices pertaining to the new systems to be inserted.

Moreover, when simulating different systems (such

25 as GSM, GPRS and UMTS cellular systems) with the prior art simulation architecture, such a high level of processing complexity can be reached as to make simulations hardly feasible: multiple implementations (one for each system) of the different modules/devices

30 are onerous in terms of processing times and are prone to lead to errors and/or to the saturation of the memory of the computer adapted to conduct the simulation.

Summary of the invention

35   The main technical problem constituting the basis

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for the present invention therefore consists of
determining a simulation architecture which enables
efficiently to conduct joint simulations of multiple
telecommunication systems or networks, operating
5 according to different standards, for instance cellular
systems of the second generation (GSM and GPRS) and of
the third generation (UMTS), WLAN networks and/or fixed
networks, the architecture being at least in part
reusable when inserting new systems.

10   According to the present invention, this problem
is solved thanks to a method having the characteristics
specifically set out in the claims that follow.

        The invention also relates to a corresponding
simulator, to the network resulting from the
15 application of the method according to the invention,
and to the related computer product able to be loaded
into the memory of at least and electronic computer and
comprising portions of software code to carry out the
steps of the method according to the invention: in this
20 context, said term shall be considered wholly
equivalent to the mention of a means which is legible
by a computer and which comprises instructions to
control a computer system in order to implement a
method according to the invention.

25   The reference to "at least an electronic computer"
is clearly meant to highlight the possibility of
embodying the solution according to the invention using
a decentralised architecture.

        The invention solves the technical problem
30 described above, introducing a simulation architecture
whereby it is possible, for instance, to conduct joint
simulations of multiple cellular systems (such as GSM,
GPRS and UMTS) or different communication networks such
as WLAN networks (802.11b, Hyperlan 2, …) or fixed
35 networks.

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A currently preferred embodiment of the invention entails the implementation of a method for simulating telecommunication networks by means of an object-based architecture, in which each object represents the model
5 of an entity of the network, the simulated network being capable of corresponding to a plurality of different "systems".

In the present context, the term "system" identifies a plurality of elements, mutually co-
10 ordinated according to a given criterion or set of criteria (i.e., a "standard") to serve a given function, i.e. to function as a communication network. For example, the term "system" here is meant to refer in distinct fashion to a "GSM system", a "GPRS system",
15 a "UMTS system", a "WLAN system" corresponding to a given standard, and so on.

For simulation purposes, in the currently preferred embodiment of the invention, the physical network devices are subdivided into:
20 - a first set of devices, completely independent of the system that regulates the operation of the network: the operation of the devices of said first set is thus independent of said system,

- a second set of devices which depend on the
25 system under consideration: the operation of the devices included in said second set is thus specific for the system under consideration (for example, in the case of a mobile network, the second set may comprise the mobile terminal devices, each having an
30 architecture that is characteristic of the individual system), and

- a third set of devices for the inter-work between the system-independent devices and the devices which do depend on the system under consideration
35 (interworking): the operation of the devices of said

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third set can be associated both to said first set and to said second set and can be identical for at least some of the systems of the aforesaid plurality.

The simulation architecture comprising said sets
5 of devices is therefore capable of allowing to simulate a network operating according to the aforesaid plurality of systems, according to a joint simulation scheme involving multiple systems.

With specific reference to the possible
10 application of the simulation of mobile communication networks, an embodiment of the solution described herein is based on the following classification of the physical devices of a cellular network:

- physical mobile radio terminal devices;
15 - physical devices of the access network (specific physical devices of the system under consideration): BTS and BSC for GSM/GPRS; NodeB and RNC for UMTS;

- physical devices of the so-called Core Network: MSC, SGSN and GGSN;
20 - physical devices of the fixed network, such as a generic switching node (Network Switching Centre or NSC) of a circuit switched network or a generic host (HOST) in which resides an application server of a packet switched network.
25 The acronyms provided above (and in the remainder of the description) are well known to those versed in the art, which makes it superfluous to provide a more detailed explanation thereof in this description.

Based on the above classification, the solution
30 described herein provides for the devices present in the simulator and relating to the physical devices of the network to be catalogued (or organised) as follows:

- devices that are completely independent of the system under consideration: these are the devices that
35 simulate the devices of the fixed network; the modules

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present in the devices of this group are common and the operation is identical for every system;

- devices which depend on the system under consideration: these are, for example, the devices that
5 simulate the physical devices of the access network (BTS and BSC for GSM/GPRS; NodeB and RNC for UMTS) or the mobile radio terminals of the different cellular systems; the modules present in the devices of this group are specific for each system and in particular
10 the devices that simulate the mobile radio terminals of the different cellular systems have a particular architecture described below; and

- interworking device: these are the devices that simulate the physical devices of the Core Network MSC,
15 SGSN and GGSN; said devices operate in such a way as to interact between the access modules and devices (which belong to the second set) and the fixed network modules and devices (which belong to the first set). For example, in the case of the GSM, GPRS and UMTS systems,
20 the modules present in the devices of this group are common to the different 2G and 3G systems and their implementations are able to manage the procedures for each individual system.

In the solution described herein, each mobile
25 radio terminal device is constituted by a part that is common for all the systems and by a part that is specific of the individual system under consideration. In particular, according the solution described herein in the mobile radio terminal device there is a grouping
30 of the modules that simulate the behaviour of the different real protocols in the following manner:

- application modules: these are common to all systems, so the same implementation is used by all radio access systems; they are grouped in the Terminal
35 Equipment (TE);

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- radio access modules: these are the specific modules of the system under consideration; and

- core network modules: these are the modules that serve interworking functions between the application

5 modules and the radio access modules; in the case of the GSM, GPRS, and UMTS systems, said modules have mutually equivalent operation, as the system changes.

In the case of the simulated GSM, GPRS and UMTS systems, the set of the application modules grouped in

10 the Terminal Equipment (TE) and of the core network modules grouped in the Mobile Terminal (MT) is indicated as Mobile Unit (MU). According to the solution described herein, a single GSM, GPRS and UMTS mobile radio terminal device is constituted by the

15 composition of the Mobile Unit (MU) and of the specific radio access modules of the system under consideration.

For example, in the case of UMTS terminal, the device is called User Equipment (UE) and it is constituted by the Mobile Unit (MU) and by the radio

20 access modules of the UMTS system.

The architecture according to the solution described herein also allows to rationalise communication between the modules and the simulated devices.

25 The following situation takes place:

- the application modules of the mobile radio terminals, which are independent of the simulated system and are grouped in the Terminal Equipment (TE), communicate with the modules present in the fixed

30 network devices (NSC and HOST);

- the radio access modules of the mobile radio terminal, which depend on the simulated system, communicate with the modules present in the devices of the access network (BTS and BSC for GSM/GPRS; NodeB and

35 RNC for UMTS);

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- the core network modules of the mobile radio terminal, which are for interworking between the application modules and the radio access modules are grouped in the Mobile Terminal (MT), communicate with
5   the modules present in the core network devices (MSC, SGSN and GGSN).

The architecture described herein thus allows to simulate - in particular in joint fashion - different systems (such as GSM, GPRS and UMTS cellular systems,
10 WLAN networks and/or fixed networks) without thereby entailing such a processing complexity as to make the simulations excessively difficult, preventing the emergence of situations that are burdensome in terms of processing time and prone to lead to errors and/or to
15 the saturation of the memory of the computer adapted to conduct the situation.

An additional characteristic of the solution described herein is that, potentially, the developed architecture is not constrained by the presence of the
20 GSM, GPRS or UMTS systems, but can handle, in addition to fixed networks, any current and future radio access system (such as WLAN).

Brief description of the accompanying drawings

The invention shall now be described, purely by
25 way of non limiting example, with reference to the accompanying drawings, in which:

- Figure 1 is a general block diagram of a simulator according to the invention,

- Figure 2 is a functional block diagram
30 illustrating the context of utilisation of the simulator of Figure 1, and

- Figures 3 through 7 show, in the form of a so-called protocol stack, the implementation of different simulation architectures according to the solution
35 described herein.

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Detailed   description   of   embodiments   of   the
invention

Figure 1 shows the architecture of a simulator 10
comprising   an   engine   11   in   which   are   present   all
5 typical functionalities for managing the simulation of
a   telecommunications   network   such   as   a   mobile   radio
network, i.e.:

- Parameter Manager 11a,

- Event Scheduler 11b,

10   - memory allocation manager or Factory Manager 11c,
and

- Statistic Manager 11d.

There is also a package device 12 which contains
the   various   devices   13   representing   the   physical
15 devices of the network and the objects pertaining to
the scenario to be simulated.

Each device contains different modules, relating
to the different functionalities managed by the device
itself.   Such   a   simulator   can   be   implemented,   for
20 example, on a computer with Intel Pentium III processor
and   Microsoft   Windows   operating   system,   using   the
Microsoft Visual Studio 6.0 development environment and
the ANSI C++ programming language.

The   solution   described   herein   introduces   into   the
25 simulator   an   architecture   of   the   devices   and   of   the
related   modules   that   is   able   to   allow   processing
operations in which voice and data telephone calls with
different   systems   can   be   simulated: for   example,
simulations   can   be   conducted   simultaneously   with
30 GSM/GPRS   users   and   UMTS   users.   The   architecture
described   herein   also   takes   into   account   the
possibility that a mobile terminal may change its radio
access   system   during   the   call,   for   example   with   a
handover from GSM to UMTS or vice versa.

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The architecture shown in Figure 2 provides for the presence (at the level of simulated objects) of the following devices:

- mobile radio terminal MS/UE (Mobile Station/User
5 Equipment): this can be a mobile radio terminal that is able to manage only the GSM/GPRS (designated as MS), a mobile radio terminal that is able to manage only the UMTS system (designated as UE), or a mobile radio terminal that is able to manage the two systems
10 GSM/GPRS and UMTS (designated as MS/UE);

- devices of the GSM/GPRS access network: BTS (Base Transceiver Station) and BSC (Base Station Controller);

- devices of the UMTS access network: NodeB, RNC
15 (Radio Network Controller);

- device of the Core Network for CS (Circuit Switched) services for GSM and UMTS: MSC (Mobile Switching Centre);

- devices of the Core Network for PS (Packet
20 Switched) services for GPRS and UMTS: SGSN (Serving GPRS Support Node), GGSN (Gateway GPRS Support Node);

- devices of the fixed network for PS (Packet Switched) services: HOST;

- devices of the fixed network for CS (Circuit
25 Switched) services: NSC (Network Switching Centre).

In turn, each device contains within it several modules, relating to the protocol layers present in the real physical devices.

The device that simulates the mobile radio
30 terminal has a structure that enables the joint management of different systems like GSM/GPRS and UMTS.

It is possible to simulate mobile terminals with the following modes:

- mobile radio terminal MS (Mobile Station): this
35 terminal is able to manage only the GSM/GPRS system;

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- mobile radio terminal UE (User Equipment): a terminal capable of managing only the UMTS system;

- mobile radio terminal MS/UE: a terminal capable of managing both GSM/GPRS and UMTS systems.

5   The modules of the mobile terminals relating to the different radio access systems are grouped in the following way:

- application modules, common to all systems: the same implementation is used by all radio access
10 systems; they are grouped in the Terminal Equipment (TE). This group comprises the modules TE_APP_TCP/HTTP, TE_APP_UDP, TE_APP_RTP/RTSP, TE_APP_CS, TE_TCP, TE_UDP, TE_IP, TE_Codec;

- Core Network modules, common to the GSM/GPRS and
15 UMTS systems, but with partly different operation according to the system: they are grouped in the Mobile Terminal (MT). This group comprises the modules MT_SM, MT_GMM, MT_CC, MT_MM;

- radio access modules, specific for the system
20 under consideration.

The set of TE and MT constitutes the Mobile Unit MU as shown in Figure 3.

The device MU and the radio access layers of the GSM/GPRS system constitute the mobile terminal MS
25 (Mobile Station), as shown in Figure 4.

The device MU and the radio access layers of the UMTS system constitute the mobile terminal UE (User Equipment), as shown in Figure 5.

The device MU and the radio access layers of both
30 GSM/GPRS and UMTS systems constitute the mobile terminal MS/UE (Mobile Station/User Equipment), as shown in Figure 6.

In detail, the application modules present in the Terminal Equipment (TE) carry out the following
35 functions:

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-       PS Packet Generator (PKG): this is the module that simulates the generation of packet traffic originated by the terminal;

-       CS Call Generator: this is the module that
5   simulates the generation of circuit switched calls originated by the terminal;

-       TE_APP_TCP/HTTP   (TE   APPlication   for Transmission Control Protocol/Hyper Text Transfer Protocol): this is the module that simulates a TCP
10 based application of packet switched services, such as an HTTP (Hyper Text Transfer Protocol) o FTP (File Transfer Protocol) application;

-       TE_APP_UDP (TE APPlication for User Datagram Protocol): this is the module that simulates a UDP
15 based application of packet switched services, such as an e-mail management application;

-       TE_APP_RTP/RTSP   (TE   APPlication   Real   Time Protocol/Real Time Session Protocol): this is the module that simulates an application of streaming
20 packet switched services;

-       TE_APP_CS   (TE   APPlication   for   Circuit Service): this is the module that simulates an application of circuit switched services, such as voice;

25   -   TE_TCP (TE Transmission Control Protocol): this is the module that simulates the TCP protocol;

-       TE_UDP (TE User Datagram Protocol): this is the module that simulates the UDP protocol;

-       TE_IP (TE Internet Protocol): this is the
30 module that simulates the IP protocol;

-       TE_Codec: this is the module that simulates voice source coding.

The modules present in the Mobile Terminal (MT) carry out, in detail, the following functions:

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- MT_SM (MT Session Management): this is the module that manages the set-up and release of user sessions (user contexts) for packet switched services PS; its operation is similar for GPRS and UMTS;

5   - MT_GMM (MT Gprs Mobility Management): this is the module that manages the set-up of a connection between mobile terminal and fixed network for packet switched services PS; it has a different operation between GPRS and UMTS and it is able to manage both
10 systems independently;

- MT_CC (MT Call Control): this is the module that manages the set-up and release of the call for circuit switched services CS; its operation is similar for GSM and UMTS;

15   - MT_MM (MT Mobility Management): this is the module that manages the set-up of a connection between mobile terminal and fixed network for packet switched services CS; its operation is similar for GSM and UMTS and it is able to manage both systems independently.

20   The specific modules of the GSM/GPRS system present in the Mobile System (MS) carry out, in detail, the following functions:

- MS_SNDCP (MS SubNetwork Dependent Convergence Protocol): this is the module that simulates the
25 mapping of the characteristics of the various network layers on the underlying LLC module;

- MS_LLC (MS Logical Link Control): this is the module that simulates the set-up of the logic connection for data transfer between MS and SGSN;

30   - MS_RLP (MS Radio Link Protocol): this is the module that simulates the mapping of the circuit switched call from the upper layers to the GSM radio access modules;

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-       MS_RR (MS Radio Resource): this is the module that simulates the procedures for setting up and releasing GSM/GPRS radio resources;

-       MS_RLC/MS_RLC_Manager (MS Radio Link
5   Control): this is the module that simulates data transmission on the radio channel for packet data; the MS_RLC_Manager module manages the instancing of individual MS_RLC modules on a logic channel basis;

-       MS_MAC (MS Medium Access Control): this is
10 the module that simulates managing access to physical resources for packet switched transmission;

-       MS_DL (MS Data Link): this is the module that simulates access to physical resources for circuit switched transmission;

15   -   MS_PHY (MS PHYsical layer): this is the module that simulates radio layer transmission;

The specific modules of the UMTS system, present in the User Equipment (UE) carry out, in detail, the following functions:

20   -   UE_RLP (UE Radio Link Protocol): this is the module that simulates mapping the circuit switched call from the upper layers to the UMTS radio access modules;

-       UE_PDCP (UE Packet Data Convergence Protocol): this is the module that simulates mapping
25 packet switched data from the upper layers to the UMTS radio access modules;

-       UE_RRC (UE Radio Resource Control): this is the module that simulates the procedures for setting up and releasing GSM/GPRS radio resources;

30   -   UE_RLC/UE_RLC_Manager (UE Radio Link Control): this is the module that simulates data transmission on the radio channel; the UE_RLC_Manager module manages the instancing of individual UE_RLC modules on a Radio Bearer basis;

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- UE_MACb/UE_MACcsh/UE_MACd (UE Medium Access Control): this is the module that simulates managing access to physical resources;

- UE_PHY (UE PHYsical layer): this is the
5 module that simulates radio layer transmission.

The specific modules of the GSM/GPRS and UMTS systems present in the mobile terminal MS/UE (Mobile Station/User Equipment) carry out the functions set out above respectively for the MS terminal for the UE
10 terminal.

The BTS and BSC, NodeB and RNC devices, respectively relating to the GSM/GPRS and UMTS access networks, are specific of the individual systems and have independent implementations.

15 In the BTS device, relating to the GSM/GPRS system, the following modules are present:

- BTS_BTSM (BTS Base Transceiver Station Management): this is the module that simulates managing the signalling between BTS and BSC;

20 - BTS_PHY (BTS PHYsical layer): this is the module that simulates radio layer transmission.

In the BSC device, relating to the GSM/GPRS system, the following modules are present:

- BSC_BSSGP (BSC Base Station Subsystem Gprs
25 Protocol): this is the module that simulates managing the signalling between BSC and SGSN;

- BSC_BSSAP (BSC Base Station Subsystem Application Protocol): this is the module that simulates managing the signalling between BSC and MSC;

30 - BSC_RLP (BSC Radio Link Protocol): this is the module that simulates mapping the circuit switched call from the upper layers to the GSM radio access modules;

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- BSC_RRM (BSC Radio Resource Management): this is the module that simulates managing radio resources for GSM and GPRS;

- BSC_RR (BSC Radio Resource): this is the
5 module that simulates the procedures for setting up and releasing GSM/GPRS radio resources;

- BSC_RLC/BSC_RLC_Manager (BSC Radio Link Control): this is the module that simulates data transmission on the radio channel for packet switched
10 data; the BSC_RLC_Manager module manages the instancing of individual BSC_RLC modules on a user and logic channel basis;

- BSC_MAC/BSC_MAC_Manager (BSC Medium Access Control): this is the module that simulates managing
15 access to physical resources for packet switched transmission; the BSC_MAC_Manager module manages the instancing of individual BSC_MAC modules on a cell basis;

- BSC_DL/BSC_DL_Manager (BSC Data Link): this
20 is the module that simulates access to physical resources for circuit switched transmission; the BSC_DL_Manager module manages the instancing of individual BSC_DL modules on a cell basis;

- BSC_BTSM (BSC Base Transceiver Station
25 Management): this is the module that simulates managing the signalling between BSC and BTS.

In the NodeB device, relating to the UMTS system, the following modules are present:

- NodeB_RRC (NodeB Radio Resource Control):
30 this is the module that simulates broadcasting system information;

- NodeB_RLC/NodeB_RLC_Manager (NodeB Radio Link Control): this is the module that simulates data transmission on the radio channel of system
35 information; the NodeB_RLC_Manager module manages

instancing individual NodeB_RLC modules on a cell
basis;

-       NodeB_MACb/NodeB_MACb_Manager (NodeB Medium
Access Control): this is the module that simulates
5 managing access to physical resources for the
transmission   of   system   information;   the
NodeB_MACb_Manager module manages the instancing of
individual NodeB_MACb modules on a cell basis;

-       NodeB_NBAP (NodeB Application Protocol): this
10 is the module that simulates managing the signalling
between NodeB and RNC;

-       NodeB_PHY (NodeB PHYsical layer): this is the
module that simulates radio layer transmission; it has
a particular architecture able to manage the common
15 channels (NodeB_CommonContext) and users' dedicated
channels (NodeB_CommunicationContext).

In the RNC device, relating to the UMTS system,
the following modules are present:

-       RNC_RANAP   (RNC   Radio   Access   Network
20 Application Protocol): this is the module that
simulates managing the signalling between RNC and
MSC/SGSN;

-       RNC_GTP_U (RNC Gprs Tunnelling Protocol User
plane): this is the module that simulates the
25 transmission of user data between RNC and SGSN;

-       RNC_RLP (RNC Radio Link Protocol): this is
the module that simulates mapping the circuit switched
call from the upper levels to the UMTS radio access
modules;

30   -   RNC_PDCP/RNC_PDCP_Manager (RNC Packet Data
Convergence Protocol): this is the module that
simulates mapping packet switched data from the upper
layer to the UMTS radio access modules; the
RNC_PDCP_Manager modules manages the instancing of the
35 individual modules RNC_PDCP on a user basis;

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- RNC_SRRM/RNC_CRRM (RNC Serving/Controlling Radio Resource Management): this is the module that simulates managing radio resources for UMTS;

- RNC_RRC (RNC Radio Resource Control): this is
5 the module that simulates the procedures for setting up and releasing UMTS radio resources;

- RNC_RLC/RNC_RLC_Manager (NodeB Radio Link Control): this is the module that simulates data transmission on the radio channel destined to system
10 information; the RNC_RLC_Manager module manages the instancing of individual RNC_RLC modules on a user and Radio Bearer basis;

- RNC_MACcsh-d/RNC_MACcsh-d_Manager (RNC Medium Access Control): this is the module that simulates
15 managing access to physical resources for the transmission of system information; the RNC_MACcsh-d_Manager module manages the instancing of RNC_MACcsh-d individual modules on a cell and user basis;

- RNC_NBAP (RNC Application Protocol): this is
20 the module that simulates managing the signalling between RNC and NodeB;

- RNC_L1 (RNC Layer 1): this is the module that simulates transmitting user data to the NodeB; it has a particular architecture, capable of managing the
25 various users with separate sessions or contexts.

In the CS and PS Core Network devices (MSC for CS, SGSN and GGSN for PS) the modules are common to the different systems and the implementations are able to manage the procedures for each individual GSM/GPRS or
30 UMTS system.

In detail, the SGSN device (see Figure 7) contains the following modules:

- SGSN_GTP_C (SGSN Gprs Tunnelling Protocol Control plane): this is the module that simulates the

transmission of the signalling between SGSN and GGSN; Its operation is similar for GPRS and UMTS;

- SGSN_GTP_U (SGSN Gprs Tunnelling Protocol User plane): this is the module that simulates the transmission of user data between SGSN and GGSN; its operation is similar for GPRS and UMTS;

- SGSN_SM/SGSN_SM_Manager (SGSN Session Management): this is the module that manages the set-up and release of user sessions for packet switched services PS; its operation is similar for GPRS and UMTS; the SGSN_SM_Manager module manages the instancing of the individual modules SGSN_SM on a user basis;

- SGSN_GMM/SGSN_GMM_Manager (SGSN Gprs Mobility Management): this is the module that manages the set-up of a connection between mobile terminal and fixed network for packet switched services PS; its operation is different for GPRS and UMTS and it is able to manage both systems independently; the SGSN_GMM_Manager module manages the instancing of the individual modules SGSN_GMM on a user basis;

- SGSN_UMTS_BS_Manager (SGSN UMTS Bearer Service Manager): this is the module that manages the data channel between user and fixed network for packet switched services PS in the case of UMTS system; in the module, each user is managed with a different UE_context;

- SGSN_RANAP (SGSN Radio Access Network Application Protocol): this is the module that simulates managing the signalling between SGSN and RNC; it is present only in the case of UMTS system;

- SGSN_SNDCP (SGSN SubNetwork Dependent Convergence Protocol): this is the module that simulates mapping the characteristics of the various network levels on the underlying LLC module; it is present only in the case of GPRS system;

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- SGSN_LLC (SGSN Logical Link Control): this is the module that simulates the set-up of the logic connection for transferring data between MS and SGSN; it is present only in the case of GPRS system;

5 - SGSN_BSSGP (SGSN Base Station Subsystem GPRS Protocol): this is the module that simulates managing the signalling between SGSN and BSC; it is present only in the case of system GPRS.

In detail, the device GGSN contains the following 10 modules:

- GGSN_IP/GGSN_IP_Manager (GGSN Internet Protocol): this is the module that simulates the protocol IP. Its operation is similar for GPRS and UMTS;

15 - GGSN_PDP_Context_Manager (GGSN Packet Data Protocol Context Manager): this is the module that stores user contexts for packet switched services PS; its operation is similar for GPRS and UMTS;

- GGSN_GTP_C (GGSN Gprs Tunnelling Protocol 20 Control plane): this is the module that simulates the transmission of signalling between GGSN and SGSN; its operation is similar for GPRS and UMTS;

- GGSN_GTP_U (GGSN Gprs Tunnelling Protocol User plane): this is the module that simulates the 25 transmission of user data between GGSN and SGSN; its operation is similar for GPRS and UMTS.

In detail, the MSC device contains the following modules:

- MSC_Codec: this is the module that simulates 30 adapting voice source coding to the coding used in the radio environment; its operation is similar for GSM and UMTS;

- MSC_CC/MSC_CC_Manager (MSC Call Control): this is the module that manages the set-up and release 35 of the call for circuit switched services CS; its

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operation is similar for GSM and UMTS. The MSC_CC_Manager module manages the instancing of the individual modules MSC_CC on a user basis;

- MSC_MM/MSC_MM_Manager (MSC Mobility
5 Management): this is the module that manages the set-up of a connection between mobile terminal and fixed network for packet switched services PS; its operation is similar for GSM and UMTS and it can manage both systems independently. The MSC_MM_Manager module
10 manages the instancing of the individual modules MSC_MM on a user basis;

- MSC_UMTS_BS_Manager (MSC UMTS Bearer Service Manager): this is the module that manages the data channel between user and fixed network for packet
15 switched services PS in the case of UMTS system; in the module, each user is managed with a different UE_context;

- MSC_RANAP (MSC Radio Access Network Application Protocol): this is the module that
20 simulates managing the signalling between MSC and RNC; it is present only in the case of UMTS system;

- MSC_BSSAP (MSC Base Station Subsystem Application Protocol): this is the module that simulates managing the signalling between BSC and MSC;
25 it is present only in the case of GSM system.

In fixed network devices (NSC and HOST) the modules are common and operation is identical for each system under consideration.

In detail, the NSC device contains the following
30 modules:

- CS Call Generator: this is the module that simulates the generation of circuit switched calls originated by the network;

- NSC_APP_CS/NSC_APP_CS_Manager (NSC
35 APPlication Circuit Service): this is the module that

simulates an application of circuit switched services, come la voce; the NSC_APP_CS_Manager module manages the instancing of the individual modules NSC_APP_CS on a user basis.

5   In detail, the device HOST contains the following modules:

-    PS Packet Generator (PKG): this is the module that simulates the generation of packet traffic originated by the network;

10   -   PSS Stream Generator (PSSG): this is the module that simulates the generation of streaming packet traffic;

-    HOST_Streaming_Server: this is the module that simulates a server of streaming packet switched

15 services, where videos reside;

-    HOST_APP_TCP/HOST_APP_TCP_Manager   (HOST APPlication Transport Control Protocol): this is the module that simulates a TCP based application of packet switched services, such as an FTP (File Transfer

20 Protocol) application; the HOST_APP_TCP_Manager module manages the instancing of individual HOST_APP_TCP modules on a user basis;

-    HOST_HTTP/HOST_HTTP_Manager (HOST Hyper Text Transfer Protocol): this is the module that simulates

25 an http application; the HOST_HTTP_Manager module manages the instancing of individual HOST_HTTP modules on a user basis;

-    HOST_APP_UDP (HOST APPlication User Datagram Protocol): this is the module that simulates a UDP

30 based application of packet switched services, such as an e-mail management application;

-    HOST_APP_RTP/HOST_APP_RTSP (HOST APPlication Real Time Protocol/Real Time Session Protocol): this is the module that simulates an application of streaming

35 packet switched services;

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- HOST_TCP/HOST_TCP_Manager (HOST Transport Control Protocol): this is the module that simulates the TCP protocol; the HOST_TCP_Manager module manages the instancing of individual HOST_TCP modules on a user basis;

- HOST_UDP (HOST User Datagram Protocol): this is the module that simulates the UDP protocol;

- HOST_IP (HOST Internet Protocol): this is the module that simulates the IP protocol.

The simulator architecture described herein can be implemented with any type of computer, such as Intel, SUN, Apple,... and with any operating (Windows, Linux, Unix, MAC OS...). Use of the ANSI C++ programming language is only one of several available options; the simulator can also be implemented in other programming languages, such as Java, Delphi, Visual Basic,... Currently, the selection of the ANSI C++ is considered preferential because it is dictated by the good programming flexibility offered by said programming language and by the high level of performance achievable in the finished program in terms of speed of execution.

The architecture of the devices and of the related modules, in general, allows to use different systems from those set out herein, such as GSM/GPRS and UMTS: any future cellular system can be simulated.

What is particularly noteworthy is that the modules of the mobile terminals relating to the different radio access systems have been grouped in the manner set out above:

- application modules, common to all systems: the same implementation is used by all radio access systems; they are grouped in the Terminal Equipment (TE). This group comprises the modules TE_APP_TCP/HTTP,

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TE_APP_UDP, TE_APP_RTP/RTSP, TE_APP_CS, TE_TCP, TE_UDP,
TE_IP, TE_Codec;

     - radio access modules: these are specific of the
system under consideration;

5   - Core Network modules, common to the GSM/GPRS and
UMTS systems, but with partly different operation
according to the system: they are grouped in the Mobile
Terminal (MT); This group comprises the modules MT_SM,
MT_GMM, MT_CC, MT_MM.

10   The architecture according to the present
invention thus allows to rationalise the simulation of
a network comprising a plurality of systems.

     According to the communication between the modules
and the simulated devices:

15   - the application modules of the mobile radio
terminal, which are independent of the simulated system
and are grouped in the Terminal Equipment, communicate
with the modules present in the devices of the fixed
network;

20   - the radio access modules of the mobile radio
terminal, which are dependent on the simulated system,
communicate with the modules present in the devices of
the access network;

     - the core network modules of the mobile radio
25 terminal, which are for interworking between the
application modules and the radio access modules and
are grouped in the Mobile Terminal, communicate with
the modules present in the core network devices.

     In the case of cellular systems not corresponding
30 or not directly deriving from current standards (GSM,
GPRS, UMTS) expressly referred in the description
provided herein by way of example, the application
modules grouped in the Terminal Equipment (TE) will
remain identical, because they are wholly independent
35 of the system in use. The core network modules grouped

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in the Mobile Terminal (MT) may be modified or
replaced, depending on the characteristics of the
systems under consideration. Lastly, the radio access
modules (and only these modules) will have to be
5 completely designed because they are specific of the
system under consideration.

The above can also be extended to modules that
simulate protocol layers of the fixed network where, as
described above, there are the following groupings:

10   - application modules: all the modules present in
      the HOST and NSC devices;

         - radio access modules: all the modules present in
      the BTS, BSC, NodeB, RNC devices;

         - Core Network modules: all the modules present in

15   the SGSN, GGSN, MSC devices.

In the case of cellular systems not corresponding
or not directly deriving from current standards (GSM,
GPRS, UMTS) expressly referred in the description
provided herein by way of example, the application

20 modules present in the HOST and NSC devices will remain
identical, because they are wholly independent of the
system in use. The core network modules present in the
SGSN, GGSN and MSC devices may be modified or replaced,
depending on the characteristics of the systems under

25 consideration. Lastly, the radio access modules (and
only these modules) will have to be completely designed
because they are specific of the system under
consideration.

It is therefore readily apparent that, without

30 altering the principle of the invention, the
construction details and the embodiments may vary
widely relative to what is described and illustrated
herein, without thereby departing from the scope of the
present invention, as defined in the appended claims.

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